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Biogeosciences Discussions

Interactive comment on "Disturbances of Biological Soil Crust by fossorial birds increase plant diversity in a Peruvian desert" *by* María Cristina Rengifo and Cesar Arana

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This manuscript analyses the effect of biopedturbations on soil properties and plant abundance and diversity compared to BSCs, which is a very uncommon topic in the scientific literature regarding BSC and which makes the content of the manuscript interesting and novel. However, I have some concerns about the design of the experiment and discussion of the results obtained, especially regarding the effect of BSC on plant diversity and abundance. I have three main points to highlight: First, different plots have been set up and samples have been collected from different places for soil moisture, chemical properties and seedling analyses, so it makes difficult to establish direct

relationships between soil properties and abundance and diversity of plants in BSCs and biopedturbations. Nevertheless, if results about soil properties and seed bank and seedlings are presented, authors should make an effort to discuss these results in an integrated way, trying to link, to some extent, the effects on soil moisture and chemical properties in BSCs and biopedturbations with the results obtained regarding plant abundance and diversity. As written now, the Discussion looks like different paragraphs addressing independent results and without linking one result with others. Second, for the chemical properties, seed bank and seedling emergence experiments (it is not clear to me if also for the soil moisture), it has been compared BSC and the removed soil by biopedturbation (which is on top of a BSC), but not undisturbed soil devoid of BSC (or bare soil). This is important to really understand the effect of BSC on soil properties and plant establishment, as compared to bare soils. Third, it is said that BSCs have a negative effect on plants, but this conclusion is not clear to me from the experiments conducted and the results obtained as, on one hand, there is no comparison of the BSC with bare soil to clearly understand the effect of the BSC and, on the other hand, the disturbed soil (by biopedturbation) lies on the BSC and thus, the BSC might have indirect effects on seedling emergence by contributing with longer moisture retention and higher nutrient release to the mound of sand. The authors should discuss these points adequately in the manuscript. As a general comment, the language of the manuscript should be thoroughly revised by an English native speaker. More detailed comments are: Page 4, MM. Were samples for soil moisture, chemical properties and seedlings determination taken in areas next to each other? Also, indicate the period in which soil sampling was done (dry or wet season). Page 4, P10: What does "experimental plot" (after "the bare soil plot") mean? Please, explain the meaning of "active" and "inactive" biopedturbations. Page 4, P15. It is said that soil moisture was measured at three times, but what do days 0, 5 and 60 represent? If they are three independent measurements at three different times, it should be represented as time 1, time 2 and time 3 (or by the date) but not as a cumulative time since an initial time. In addition, the sentence "At day 0 the bare soil plot was sample with the undisturbed

BSC layer, and immediately after the collection of the sample the BSC was removed" is not understandable. Was the bare soil plot soil devoid of BSC or soil with BSC in which the crust was removed? In the latter case, it is not measured soil moisture content in bare soil but in the soil underneath the crust. The soil below the BSC usually has better properties (higher EPS, N, aggregation...) than the bare soil and thus, soil moisture is likely higher in the soil beneath the crust than in adjacent soils devoid of BSC. If the BSC was removed from the soil and water content was measured in the underlying soil in day 0, what was measured after 5 and 60 days? Soil moisture in the scalped soil? Both measurements are not comparable because in day 0 the presence of the BSC conditions soil moisture in the underlying soil, while in the resting days, soil water content is measured in soil lacking the BSC. I think authors should show soil moisture data only for the days in which similar surface types are compared, and in the case of the bare soil, let clear that it consists of scalped soil where the top BSC was removed (which is not the same than bare soil).

Regarding the method, if moisture content is determined by weight, it is gravimetric water content (g H2O/kg soil), not volumetric water content. Page 4, P20. Which soil depth was sampled for the analysis of chemical properties? Besides, the method used for the determination of each soil property should be explained. Page 4, P25. Please, homogenize the terminology for biopedturbation samples as different terms are used along the text ("biopedturbation plot", "removed soil from the loose soil of the entrance of the burrows", "disturbed soil"). Page 5. It should be included a section of "data treatment" or "statistical analyses" to explain how statistical differences were analysed and also to explain the indices of plant abundance or diversity used. Page 5. In general, description of the results is very poor and should be greatly improved. Authors should describe more in detail differences in the properties analysed between BSC and piopedturbations. Page 5, P5. Please, describe first differences in soil moisture among times (also explains what the different times represent), and then, differences among "bare soil" (see my comment above), BSC and types of biopedturbations. Page 5, P10. Results of chemical properties should be better described by comparing the BSC with

the underlying soil and both with the disturbed soil for all soil properties. For instance, it could be shown average values of the different properties in BSCs compared to disturbed soil, Pages 5-6. The Discussion should be substantially improved. Authors should make an effort to connect the different results obtained and, for instance, try to link the results of seed bank and seedlings with the results of soil moisture, organic matter and nutrients in BSC and biopedturbations. The manuscript should be also improved by comparing with other published studies that analyse the effect of biopertudbations on seedlings and by adequately explaining and discussing the positive and negative effects of BSC on seedling and plant establishment, and relating these effects with their effects on soil properties. I also recommend using more recent references in the Discussion as some of them are old and there is a large budget of articles recently published about the influence of BSC on soil properties (water content, nutrients...). Page 6, P5-10. In this paragraph it is said that in the piopedturbation, the mound of sand is on top of the BSC. If the BSC acts as a seal on the soil surface limiting water infiltration into deeper soil, it could have a positive effect retaining moisture at the surface and keeping moisture longer in the sand above it, indirectly favouring seedling in the mound of sand. Page 6. Soil moisture, chemical properties and seedlings in biopedturbations and BSC are discussed separately, and no relationships and interactions between these properties have been discussed. For instance, higher organic matter and nutrients in BSC could be the reason for higher plant abundance. In contrast, lower moisture could be the reason for lower diversity, as only certain species better adapted to drier conditions could be competitive for growing in soils covered by BSCs, while others with more water requirements would grow better in biopedturbation-disturbed soils. Page 6, P25-40- An important point to discuss is the different results found in the seedling greenhouse experiment and the field experiment. Such differences could be related to differences in water availability between both experiments that could strongly condition species diversity and abundance in the BSC under greenhouse and field conditions. In the greenhouse, samples were irrigated frequently and in this case, higher abundance of the seed bank was found in the BSC compared to biopedturbations,

while in the field, with limited water availability, opposite results were found. Water, thus, appears to be a major driver for seedling abundance. This should be discussed in the Discussion. Page 6, P30-35. Together with moisture availability, I really think that the reduction in seedling emergence in BSC is greatly associated to a physical impediment: the seal created by the crust impedes seed penetration and leaves the seed more exposed (and less protected) to hostile environmental factors, at the same time that facilitates seed removal by wind. Page 7, P5-10. This paragraph is confusing and mix different ideas about BSC and plant interactions. The authors should explain along the Discussion the contrasting effects of BSC on vegetation, and why they can have positive and negative effects on vegetation. The sentence "At the same time, vegetation provides a positive effect to the BSC (Bowker, 2007), and because photosynthetic organisms compete to each other for resources, a negative effect is also expected" is not understandable and contradictory as it suggests a simultaneous positive and negative effect of vegetation on BSC. I do not think plants and BSC compete for water and nutrient resources, but that BSCs grow in the areas where water and nutrients are not available enough to allow plant establishment.

The sentence "and at a landscape scale the presence of ecosystem engineer would result in an increase of the species richness, along with the Competitive exclusion principle of Gause (Palmer, 1994) coexistence is allowed, and as a result vegetation increases its abundance and richness in an indirect way." is very abstract and not understandable in this context. Please, either rewrite it or delete this sentence.

Page 7, P20. What do the authors mean by "relationships of a high order interaction"? It is not clear that BSCs have a negative effect on the plant community and that "biopedturbations attenuate the negative effect of BSC to the plant community". Likely, BSCs could have an indirect effect on the disturbed soil by maintaining soil moisture longer and by contributing nutrients to the mound of sands. In addition, it has not been analysed seedling abundance and diversity in BSCs compared to bare soil. Some editing comments: Is the term "biopedturbation" more commonly used than "bioturbation"?

The second one is more familiar to me. Page 4, P35. "We consider 15 replicates for each type of biopedturbation" Page 5, P15. "...where the BSC samples had a higher abundance of germinated seeds than active and inactive biopedturbations." Figure 2. Include the units for soil moisture in axis Y. In addition, units in the legend seem to be wrong (gH2O/kg soil, not

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